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Battling the challenges of training nurses to use information systems through theory-based training material design

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Abstract. The attempts to train nurses to effectively use information systems have had mixed results. One problem is that training materials are not adequately designed to guide trainees to gradually learn to use a system without experiencing a heavy cognitive load. This is because training design often does not take into consideration a learner's cognitive ability to absorb new information in a short training period. Given the high cost and difficulty of organising training in healthcare organisations, there is an urgent need for information system trainers to be aware of how cognitive overload or information overload affect a trainee's capability to acquire new knowledge and skills, and what instructional techniques can be used to facilitate effective learning.

This paper introduces the concept of cognitive load and how it affects nurses when learning to use a new health information system. This is followed by the relevant strategies for instructional design, underpinned by the principles of cognitive load theory, which may be helpful for the development of effective instructional materials and activities for training nurses to use information systems.

Keywords. Cognitive load, information system, instructional design, learning, nurse, training

Introduction

Training is necessary for novice users to learn how to use a new information system. It is crucial for users to accept and use the system [1-3]. Effective training allows learners to develop the knowledge and skills needed for effective use of the system. However, to date the training of registered or enrolled nurses to use health information systems (HIS) in hospital settings has had mixed results.

For example, Adaskin et al. [4] conducted a study in a large Canadian hospital to investigate the impact of an HIS on nursing. Training of nurses was completed one day before the system went live. Then the training module 'Play Hospital' was set up and made available to all units. Contrary to the intention of the project manager, nurses resisted practicing to use the system because they felt overwhelmed in using it. This was an indication that the basic training was ineffective and the trainees did not acquire the essential knowledge and skills to enable them to explore the system on their own.

One of the reasons was the large amount of content that was delivered in a short one day period, which overloaded their cognitive ability with too much new information.

Whittaker et al. [5] conducted a qualitative study to evaluate the implementation of an electronic health record (EHR) system in a rural hospital where all nursing staff attended a one day introduction and training on the entire EHR system before implementation. All nurses reported that too much information was presented during training, stating that by the end of the 4th hour they could not concentrate any longer. They became frustrated and overwhelmed. In the end, both fast and slow learners reported they lacked the basic knowledge to operate the system. In the same way as in [4], nurses' cognitive capacity was overtaxed resulting in failure to learn.

An investigation into nurses' perceptions of adopting an information system in a Taiwanese medical centre reported the feedback of a selected few nurses about the training after going through a train-the-trainer session [6]. They reported that training was too short, and that they had to learn by 'trial and error'. Although such strategies can help nurses to learn to use the new system, continuous attempts to trial different features imposed a high mental load [7] that overburdened their cognitive ability resulting in frustration about and resistance to using the system. Again, the goal of training was not achieved because the training approach did not consider the learners' cognitive ability to process new information.

Nurses without proper training, as shown by results of the above studies, may view the introduction of a new HIS as adding to their workload and are likely to be frustrated with the system, become fearful of it and perceive it as time consuming [8]. Eventually, some will resist using the system. Therefore, there is an urgent need for HIS trainers to understand how cognitive load affects a learner's ability to acquire new knowledge in order to use these systems and what instructional design strategies can be used to facilitate learning without exerting an unnecessary extra mental load.

To help HIS trainers design effective training strategies and materials, this discussion paper introduces the concept of cognitive load and how it can affect a trainee's ability to learn to use a new HIS and how effective instructional design underpinned by cognitive load theory (CLT) can improve the situation.

1. Methods

A targeted literature review was conducted on how the use of CLT can facilitate information system training in a healthcare setting. The literature searches focused on HIS training and CLT studies. The following search keywords were used: HIS training, cognitive load theory, worked-out example, nursing informatics. More than 167 articles were collected and an EndNote reference database was used to organise the selected abstracts. Inclusion criteria were: studies on nursing, information systems, CLT, education and training of nurses. Exclusion criteria were publications not dealing with HIS training of nurses or CLT and duplicated articles were removed, 83 articles remained. Further assessment based on relevance to this study's focus was applied to lead to a final selection of 23 eligible papers. The search was performed on various databases with the help of library and Google scholar search engines. The language was limited to English.

2. Results

Patel et al. [9] suggest that learning theories can contribute to the effectiveness of training by providing a framework on which to develop and implement appropriate instructional design and training activities. There are three major learning theories: behaviourism, constructivism and cognitivism. Behaviourism equates learning with changes in observable behaviour, i.e., trainees change behaviour in response to stimuli. Constructivism emphasises the creation of knowledge by trainees as they attempt to make sense of their experiences. Cognitivism emphasises making knowledge meaningful and helping trainees organise and relate new information to existing knowledge in memory. Behaviourism and constructivism do not take into consideration trainees' cognitive and individual differences in learning [9]. Cognitivism emphasises these differences and advocates training to recognise the differences in human information processing capabilities. Therefore, it is considered to better support nurses' training. Cognitive load theory (CLT), one of the learning theories of cognitivism, is thus adopted to guide HIS training.

2.1. Cognitive Load Theory and Its Affect on Trainees' Ability to Learn to Use a New Information System

CLT was first proposed by Sweller [10] to explain the challenges of learning caused by the limitations of human cognitive processing abilities. According to the principles of CLT, when nurses encounter unfamiliar information in their learning to use a new HIS, that information is first held and processed in working memory (WM). However, WM is limited, particularly in the amount of information it can hold and process, because in general WM can only process two or three unfamiliar elements at a time [11]. Once information has been processed in WM, it is moved into long-term memory (LTM) for permanent storage. In contrast to WM, the capacity of LTM is unlimited.

In LTM, people's previous knowledge is stored as 'schemas', which are mental structures organised in ways convenient for future use [12]. These mental structures will allow nurses to make sense of unfamiliar information by deciding how the new information fits into previously accumulated knowledge. In fact, without the required mental structures, particularly for novice users, into which new information can be assimilated, learning to use new HIS functions is impossible and little can be learned. Schemas are easier to retrieve from LTM. In order to learn to use the new HIS, new information elements must enter and be processed in nurses' WM by being integrated simultaneously with their prior knowledge from LTM [12].

The need to consciously hold and process a large volume of unfamiliar items in the WM places significant demands on a novice user. If the demand is too high, it generates excessive load on the WM, this causes cognitive load, which is the load that is imposed by a specific task on the learner's cognitive resources when executing that task [13].

2.2. Types of Cognitive Load

There are three types of cognitive load that affect learning: intrinsic, extraneous and germane cognitive load [12]. Intrinsic cognitive load (ICL) is the result of the inherent difficulty of the content of the learning material or task. The magnitude of ICL experienced by a trainee is caused by the degree of association between crucial

elements of information needed to be considered to understand new information, therefore managing the ICL for a specific trainee may be through pre-training and presenting simplified tasks where certain elements are omitted [14].

Extraneous cognitive load (ECL) can be caused by improper organisation of training materials that introduce irrelevant or redundant information. An example is HIS training materials cluttered with text next to self-explanatory diagrams. Trainees experience ECL when they split their attention between physically separated information sources and such actions are not relevant to learning. This concept is central to CLT and has led to the development of numerous ways to reduce ECL[15].

Germane cognitive load (GCL) is the result of effortful construction and automation of the mental structures (schemas) [12]. It accounts for the conscious cognitive effort leading to learning and subsequent learning-relevant demands on WM that are beneficial to learning. Thus, the main instructional principle of CLT is to decrease ECL and increase GCL in order to prevent cognitive overload.

2.3. Effective Instructional Design for Health Information Systems Underpinned by Cognitive Load Theory

CLT focuses on the limits of the WM when an individual interacts with unfamiliar information to create new knowledge. There are three strategies underpinned by CLT that are applicable to HIS training: split-attention, redundancy and worked example effects.

The split-attention effect refers to the separate placement of interrelated information sources that are required for understanding. For instance, most training programs present information in various forms: printed screen shots, animations and diagrams with text [4]. Figure 1a demonstrates an HIS training manual that does not present procedural information in an integrated format. The graphic image is presented at the top of the screen, and the instructional information is presented underneath it as items e to h. If a trainee focuses his/her attention on the text data only, they will find it difficult to understand without linking it to the graphic image in the diagram. Thus, in order to understand this multiple sources of information, the trainee must hold the corresponding graphic image and text in WM at the same time. Some trainees may find it difficult to do this. This is likely to overload the limited WM [16], causing unnecessary cognitive overload due to sub-optimal instructional design [17].

To overcome the split-attention effect, multiple sources of information (frequently pictures and accompanying text) can be replaced with a single combined format in training materials in order to improve learning outcomes [17; 18].

The redundancy effect occurs when the same information is presented to a trainee in different forms e.g. when spoken and written text are provided concurrently [16]. The act of having to process multiple forms of the same information simultaneously imposes an EGL that results in slower learning [19]. Previous research has shown trainees learn better from multimedia lessons containing graphics and narration (see Figure 1b) than from graphics, narration, and redundant on-screen text (see Figure 1a) [see 16; 20].

For example, in Figure 1b, the training module provides minimal text and ample diagrams which reduces redundancies. It provides an example of an integrated instructional design where different types of information are integrated in one screenshot of an HIS module. The amount and the content of the information in the integrated format is the same as that in Figure 1a, but the information is presented in

close proximity and clearly linked to the relevant features of the HIS module, this design avoids split-attention and minimises redundancy.

Worked-out examples consist of a problem statement and its detailed solution steps[21]. Training designed with worked-out examples offers trainees an opportunity to learn how expert users operate the system in a similar situation. This facilitates their learning by following and emulating the actions of experts.

Using the worked-out examples strategy in HIS training, trainees are provided with a problem, which is accompanied by a step-by-step procedure on how to reach the solution. This allows trainees to be actively involved in the learning process by using expert HIS interaction to solve the problem. This strategy has been demonstrated to foster near and far transfer of learning [7; 22]. Afterwards the trainees can be requested to practise using the system through trial and error independently. Conventional practice problems are only superior to worked-out examples when trainees are more experienced [23].

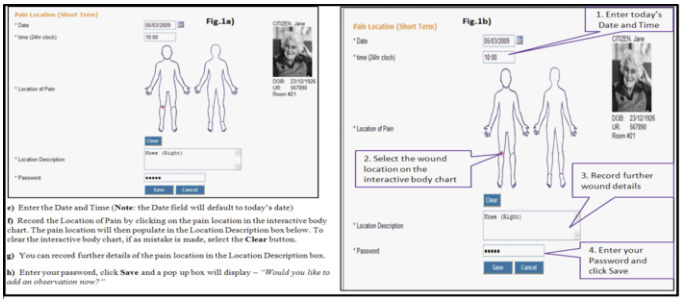

Figure 1. Training modules with text and picture a) causing split-attention and b) an integrated format.

3. Conclusion

Effective instructional design is important for improving training for nurses to learn to use information systems. Cognitive load theory, by providing an understanding about how the human brain processes new information for learning to occur provides useful guide for the development of effective training strategies and materials. According to CLT, a trainee can only hold and process two or three new information elements at one time in WM. Therefore, training materials and activities based on CLT are designed so that they do not overload the limited WM. If the capacity of the WM is exceeded, little learning will occur. This makes learning ineffective and nurses may even develop fear of or resistance towards the new HIS system to be introduced.

This paper introduces three instructional design strategies underpinned by CLT. The first strategy reduces the split-attention effect by integrating related information sources. The second strategy eliminates redundancies from instructional sources. The third strategy is to provide novice users with worked-out examples to gain the necessary basic knowledge and skills of how to operate an HIS, then gradually to lead them to learn to use it via trial and error. Pre-training nurses in basic computer skills and simplifying some tasks can assist novices who struggle in their initial attempts at learning HIS. In summary, any HIS training must consider the cognitive load effect on the trainee's ability to learn and use effective instructional design underpinned by CLT to improve learning.

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